Roll No.....

BTECH –2014

ELEMENTS OF MECHANICAL ENGINEERING

Paper Code (ME-101)

Paper Id. [A0123]

Time : 3 Hrs | Maximum Marks: 60

Note: This paper consists of three sections. Section A is compulsory. Do any three questions from section B and C selecting minimum two from each section.

Section A (2 marks each)

1. a. A constant mass goes through a process where 100 W of heat transfer comes in and 100 W of work leaves. Does the mass change state?

   b. An inventor has developed a refrigeration unit that maintains the cold space at −10°C, while operating in a 25°C room. A coefficient of performance of 8.5 is claimed. How do you evaluate this?

   c. A reversible process adds heat to a substance. If T is varying does that influence the change in s?

   d. For the same compression ratio and heat rejection, compare Otto cycle and Diesel cycle on P-v and T-s diagrams.

   e. For the same peak pressure, peak temperature and heat rejection, compare Otto cycle and Diesel cycle on P-v and T-s diagrams.

   f. What In the absence of any friction and other irreversibilities, can a heat engine have an efficiency of 100 percent?

   g. Explain Define the following: i) Resilience, ii) Proof resilience, iii) Modulus of resilience.

   h. For a material, Young's modulus is given as $1.2 \times 10^5 N/mm^2$ and Poission's ratio is 0.25. Calculate the Bulk's modulus.

   i. Draw neat sketches of any two inversions of double slider kinematic chain.

   j. Explain the terms, reversibility and irreversibility as applied to lifting machines.

Section B (8 marks each)

2. A system containing $0.2\,m^3$ of air at a pressure of $4\,bar$ and $160\,°C$ expands isentropically to a pressure of $1.06\,bar$ and this gas is heated at constant pressure till the enthalpy increases by $65\,kJ$. Calculate the work done. Now imagine that these processes are replaced by a single reversible polytropic process producing the same work between initial and final state; find the index of expansion in this case. Take $c_p = 1.005\,kJ/kg-K$.

3. i) A reversible heat engine operates under two environments. In the first it draws $12000\ kJ/s$ from a thermal source at $400°C$ and in the second environment, it draws $25000\ kJ/s$ from a thermal source at $100°C$. In both the operations, the engine rejects heat to a thermal sink at $20°C$. Determine the operation in which the engine delivers more power.
ii) Verify the statement "The efficiency of an irreversible engine is always less than the efficiency of reversible one operating between the same two thermal reservoirs".

4. Air at $105\ m/s$ and $1.25\ kg/m^3$ enters a gas turbine of the inlet area $0.05\ m^2$. The air stream exits from the gas turbine at $135\ m/s$ and $0.67\ kg/m^3$. During the flow process, the air losses $27\ kJ/kg$ of heat and its specific enthalpy comes down by $145\ kJ/kg$. Determine a) the mass flow rate of air through the turbine, b) the turbine exit area, c) the power developed by the turbine.

5. i) Define inequality of Clausius and entropy of a system. Show that for an irreversible process $ds \geq \frac{dQ}{T}$. (4)

ii) A heat engine is supplied with $278\ kJ/s$ of heat at a constant fixed temperature of $283°C$ and the heat rejection takes place at $5°C$. The following results were reported: (4)
a) $208\ kJ/s$ of heat rejected
b) $139\ kJ/s$ of heat rejected
c) $70\ kJ/s$ of heat rejectedClassify which of the results report a reversible cycle, irreversible cycle or impossible cycle.

6. i) Show that the efficiency of a Brayton cycle depends only on the pressure ratio. (4)

ii) In an air standard Brayton cycle, air enters the compressor at $300\ K$ and $1\ bar$. The pressure ratio is 8 and the maximum allowable temperature is $1300\ K$. Determine the temperature and pressure at each state of the cycle, compressor work, and turbine work per kg of air and cycle efficiency. (4)

Section C (8 marks each)

7. i) In a lifting machine an effort of $98.2\ N$ raised a load of $1000\ N$ and an effort of $498.2\ N$ raised a load of $6000\ N$. Find the law of machine. Find what effort is required to lift a load of $10000\ N$? Find also the maximum mechanical advantage. (4)
ii) Explain differential pulley block arrangement with a neat sketch and find expression for velocity ratio. (4)

8. i) Prove that the maximum stress induced in a body due to sudden applied load is twice the stress induced when the same load is applied gradually. (2)
ii) A weight W falls through $1\,cm$ on a collar attached at the bottom of avertical bar. The maximum instantaneous extension in the bar is $0.002\,mm$ for a length of $3\,m$. The area of cross-section of the bar is $6\,cm^2$. Find the corresponding stress and the weight W. Take $E = 200\,GPa$. (6)

9. i) Discuss working of a crank and slotted lever type of quick return mechanism with a neat sketch and explain its working. (4)
ii) Derive an expression for thermal efficiency of an Otto cycle and prove that for maximum work, compression ratio should be (4)

$$r = \left(\frac{T_3}{T_1}\right)^{1.25}$$

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